Ch 11 Molecular Composition of Gases

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Gay Lussac - worked w/ Reacting Gases

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$$\underset{1\,L}{H} + \underset{1\,L}{Cl} \longrightarrow \underset{2\,L}{HCl}$$

Ch 11 Molecular Composition of Gases

Gay Lussac - worked w/ Reacting Gases

$H + Cl \rightarrow HCl$

1 L 1 L 2 L

$2H + O \rightarrow H_2O$

2 L 1 L 2 L

Ch 11 Molecular Composition of Gases

Gay Lussac's Law of Combing Volumes → @ const T+P the volumes of Reacting Gases can be expressed in Ratios of small whole #'s

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Avogadro's Principle

@ const T+P equal volumes of gases have equal #'s of particles

Ch 11 Molecular Composition of Gases

Gay Lussac's Law of Combing Volumes → @ const T+P the volumes of Reacting Gases can be expressed in Ratios of small whole #'s

$H_2 + Cl_2 \rightarrow 2HCl$

1 L + 1 L → 2 L

$2H_2 + O_2 \rightarrow 2H_2O$

2 L + 1 L → 2 L

Avogadro's Principle

@ const T+P equal volumes of gases have equal #'s of particles

Avogadro Resolved the conflict by suggesting that some elements are diatomic.

Molar Volume of a gas

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↳ Based on Avogadro's Principle (Equal Vol's of gases have equal #'s of particles)

one mole of any gas will occupy the same volume @ STP!

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Molar vol @ STP $\frac{22.4\,L}{1\,mole}$

What vol w/ 8.0 mol
of CH_4 occupy STP?

How many moles are
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8.0 mol CH_4

How many moles are in 32.0 L of N_2 @ STP?

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$$8.0 \text{ mol } CH_4 \times \frac{22.4 \text{ L } CH_4}{1 \text{ mol } CH_4}$$

How many moles are in 32.0 L of N_2 @ STP?

What vol will 27.0 g of Ar occupy @ STP?

What vol w/ 8.0 mol of CH_4 occupy STP?

$$8.0 \text{ mol } CH_4 \times \frac{22.4 \text{ L } CH_4}{1 \text{ mol } CH_4} = 179.2 \text{ L } CH_4$$

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How many moles are in 32.0 L of Ne @ STP?

$$32.0 \text{ L } Ne \times \frac{1 \text{ mol } Ne}{22.4 \text{ L } Ne} = 1.43 \text{ mol } Ne$$

What vol will 27.0 g of Ar occupy @ STP?

What vol w/ 8.0 mol of CH_4 occupy STP?

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What vol will 27.0 g of Ar occupy @ STP?

$$27.0 \text{ g Ar} \times \frac{1 \text{ mol Ar}}{39.9 \text{ g Ar}}$$

What vol w/ 8.0 mol of CH_4 occupy STP?

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$$27.0 \text{ g } Ar \times \frac{1 \text{ mol } Ar}{39.9 \text{ g } Ar} \times \frac{22.4 \text{ L } Ar}{1 \text{ mol } Ar} = 15.1 \text{ L } Ar$$

Ideal Gas Law

Ideal Gas Law
(, Based other gas Laws

Ideal Gas Law
↳ Based other gas Laws

Boyle's Law $V \propto \frac{1}{P}$

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} Join Together

$V \propto n \times T \times \frac{1}{P}$

Ideal Gas Law
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$V \propto n \times T \times \frac{1}{P}$

$V = \frac{nT}{P} \times R$

Ideal Gas Law
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$V \propto n \times T \times \frac{1}{P}$

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$PV = nRT$
Ideal Gas Law

Finding R

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$PV = nRT$

$R = \frac{PV}{nT}$

Finding R

$PV = nRT$

$R = \frac{PV}{nT} = \frac{(1\,atm)}{(273\,K)}$

Finding R

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$R = \frac{PV}{nT} = \frac{(1\,atm)(22.4\,L)}{(1\,mol)(273\,K)}$

Finding R

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$R = \frac{PV}{nT} = \frac{(1\,atm)(22.4\,L)}{(1\,mol)(273\,K)}$

$R = 0.0821 \frac{L\,atm}{mol\,K}$

Ideal Gas Law

$PV = nRT$ $\quad R = 0.0821 \frac{L\,atm}{mol\,K}$

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$PV = nRT$ $\quad R = 0.0821 \frac{L\,atm}{mol\,K}$

V 20.0 L
T: 273 K
P: 1.2 atm
n = ?

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$PV = nRT$ $\quad R = 0.0821 \frac{L\,atm}{mol\,K}$

$n = \frac{PV}{RT} \quad \frac{(1.2\,atm)(20.0\,L)}{(0.0821 \frac{L\,atm}{mol\,K})(273\,K)}$

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$$= 1.07\ mol$$

What volume will
8.0 g of CH_4 be @
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P n
V T

What volume will 8.0g of CH_4 be @ 89°C and 870 torr?

P: 870 torr

V = ?

n: 8.0g CH_4

T = 89°C

What volume will 8.0 g of CH_4 be @ 89 °C and 870 torr?

$P = 870$ torr

$V = ?$

$n = 8.0\ g\ CH_4 \times \frac{1\ mol\ CH_4}{16\ g\ CH_4} = 0.5\ mol\ CH_4$

$T = 89$ °C

What volume will 8.0 g of CH_4 be @ 89 °C and 870 torr?

$P = 870 \text{ torr} \times \frac{1 \text{ atm}}{760 \text{ torr}} = 1.14 \text{ atm}$

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$V = ?$

$T = 89 °C + 273 = 362 \text{ K}$

$PV = nRT$

What volume will 8.0 g of CH_4 be @ 89 °C and 870 torr?

$V = \frac{nRT}{P} =$

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$V = ?$

$T = 89 °C + 273 = 362 \text{ K}$

$PV = nRT$

$$V = \frac{nRT}{P} = \frac{(0.5 \text{ mol})(0.0821 \frac{\text{L atm}}{\text{mol K}})(362 \text{ K})}{1.14 \text{ atm}}$$

$$= \boxed{10.6 \text{ L}}$$

Gas Stoichiometry

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vol to vol

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Vol to Vol

Gay-Lussac's Law of Combining V's

@ const T + P, V's of Reacting gases + products can be expressed in Ratios of small whole #'s

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$H_2 + Cl_2 \rightarrow 2HCl$

1L

Gas Stoichiometry

Vol to Vol

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$H_2 + Cl_2 \rightarrow 2HCl$

1L 1L 2L

If 3L H_2 React, How many L of HCl are produced?

$3L\ H_2 \times \frac{2L\ HCl}{1L\ H} = 6L\ HCl$

Just like mol-mol stoich

$N_2 + H_2 \rightarrow NH_3$

If 47 mL of H_2 React what v of N_2 is also Req'd @ STP?

$N_2 + 3H_2 \longrightarrow 2NH_3$

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$47\,mL\,H_2 \times$

$N_2 + 3H_2 \longrightarrow 2NH_3$

If 47 mL of H_2 react what v of N_2 is also Req'd @ STP?

$47\,mL\,H_2 \times \frac{1\,mL\,N_2}{3\,mL\,H_2} = 15.7\,mL$

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

If 47 mL of H_2 React what v of N_2 is also Req'd @ STP?

$$47\,mL\,H_2 \times \frac{1\,mL\,N_2}{3\,mL\,H_2} = 15.7\,mL$$

$$47\,mL\,H_2 \times \frac{1\,L\,H_2}{1000\,mL\,H_2} \times \frac{1\,mol\,H_2}{22.4\,L\,H_2} \times \frac{1\,mol\,N_2}{3\,mol\,H_2} \times \frac{22.4\,L\,N_2}{1\,mol\,N_2} \times \frac{1000\,mL\,N_2}{1\,L\,N_2}$$

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

If 47 mL of H_2 React what v of N_2 is also Req'd @ STP?

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$$47\text{ mL } H_2 \times \frac{1\text{ L } H_2}{1000\text{ mL } H_2} \times \frac{1\text{ mol } H_2}{22.4\text{ L } H_2} \times \frac{1\text{ mol } N_2}{3\text{ mol } H_2} \times \frac{22.4\text{ L } N_2}{1\text{ mol } N_2} \times \frac{1000\text{ mL } N_2}{1\text{ L } N_2}$$

Gas Stoichiometry

Vol to Vol

Gay-Lussac's Law of Combining V's

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↳ Equal to Molar Ratios

$H_2 + Cl_2 \rightarrow 2HCl$

1L 1L 2L

If 3L H_2 React, How many L of HCl are produced?

Gas Stoichiometry

Vol to Vol

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If 3L H_2 React, How many L of HCl are produced?

$3L\ H_2 \times \frac{2L\ HCl}{1L\ H_2} = 6L\ HCl$

Gas Stoich

$2H_2 + O_2 \longrightarrow 2H_2O$

If 4.0g H_2 React w/ an excess of O_2 what volume of H_2O will be produced @ STP?

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$4.0g\ H_2\ x$

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$2H_2 + O_2 \longrightarrow 2H_2O$

If 4.0g H_2 React w/ an excess of O_2 what volume of H_2O will be produced @STP?

$4.0\,g\,H_2 \times \frac{1\,mol\,H_2}{2\,g\,H_2}$

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$$4.0\,\cancel{g\,H_2} \times \frac{1\,\cancel{mol\,H_2}}{2\,\cancel{g\,H_2}} \times \frac{2\,mol\,H_2O}{2\,\cancel{mol\,H_2}} \times \frac{22.4\,L\,H_2O}{1\,mol\,H_2O} =$$

Gas Stoich

$2H_2 + O_2 \longrightarrow 2H_2O$

If 4.0 g H_2 React w/ an excess of O_2 what volume of H_2O will be produced @ STP?

$$4.0\,\cancel{g\,H_2} \times \frac{1\,\cancel{mol\,H_2}}{2\,\cancel{g\,H_2}} \times \frac{2\,\cancel{mol\,H_2O}}{2\,\cancel{mol\,H_2}} \times \frac{22.4\,L\,H_2O}{1\,\cancel{mol\,H_2O}} = 44.8\,L\,H_2O$$

Gas Stoich

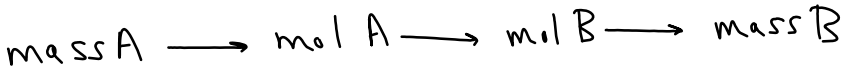
$2H_2 + O_2 \longrightarrow 2H_2O$

If 4.0 g H_2 React w/ an excess of O_2 what volume of H_2O will be produced @ STP?

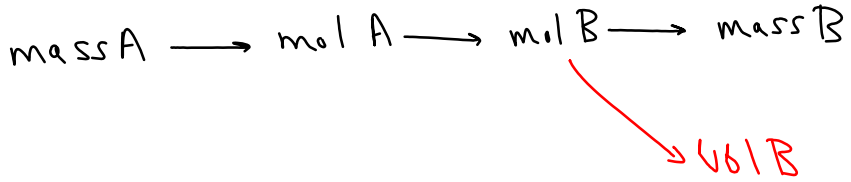
$4.0\,g\,H_2 \times \frac{1\,mol\,H_2}{2\,g\,H_2} \times \frac{2\,mol\,H_2O}{2\,mol\,H_2} \times \frac{22.4\,L\,H_2O}{1\,mol\,H_2O} = 44.8\,L\,H_2O$

mass A $\longrightarrow$ mol A $\longrightarrow$ mol B $\longrightarrow$ vol B

Stoich flowchart

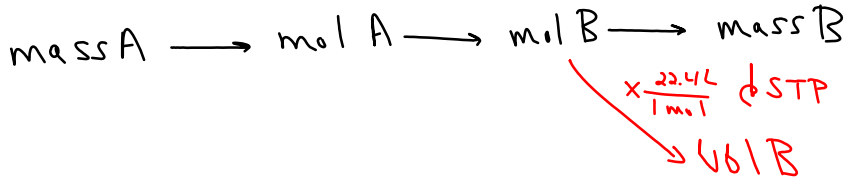


Stoich flowchart



Gases

Stoich flowchart



Gases

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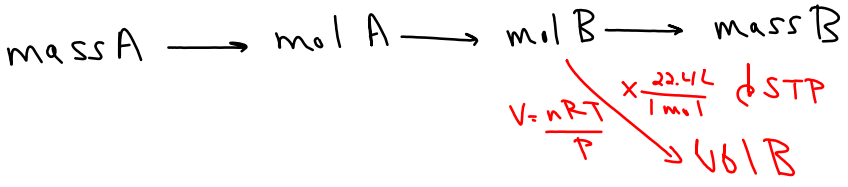
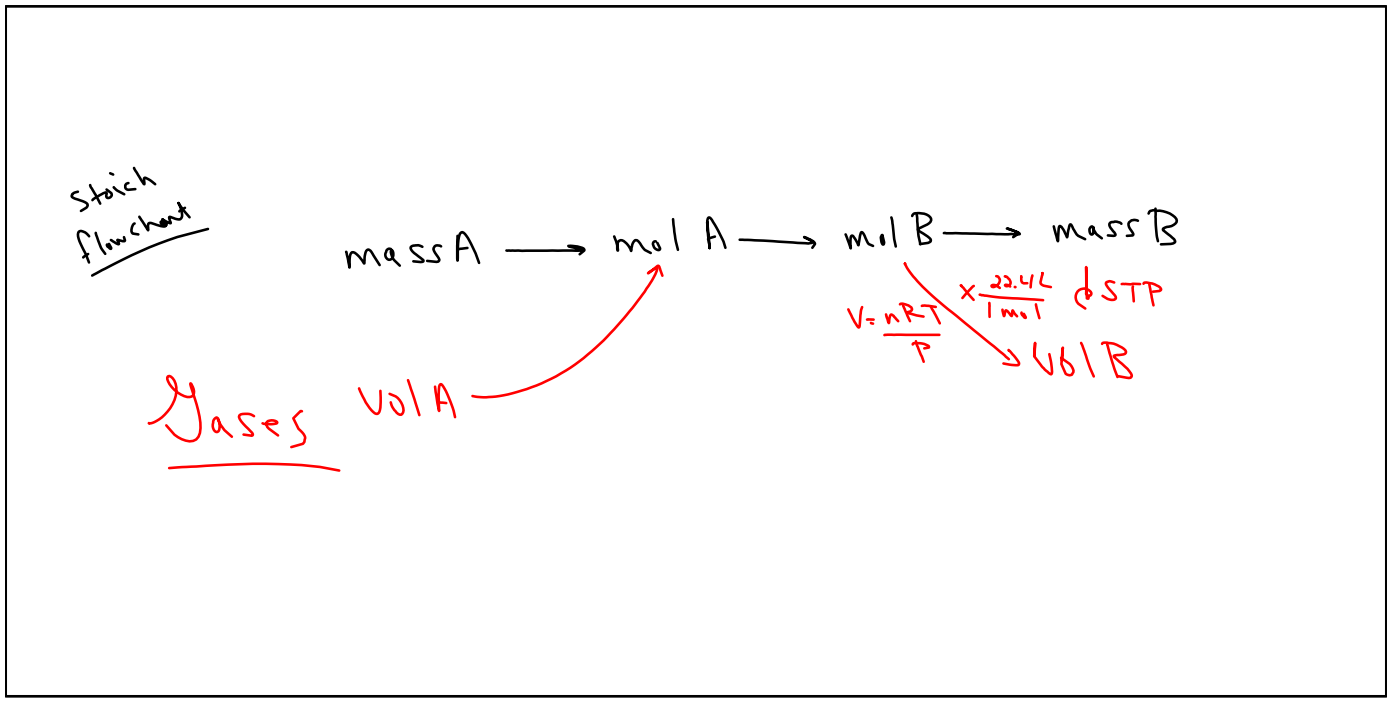
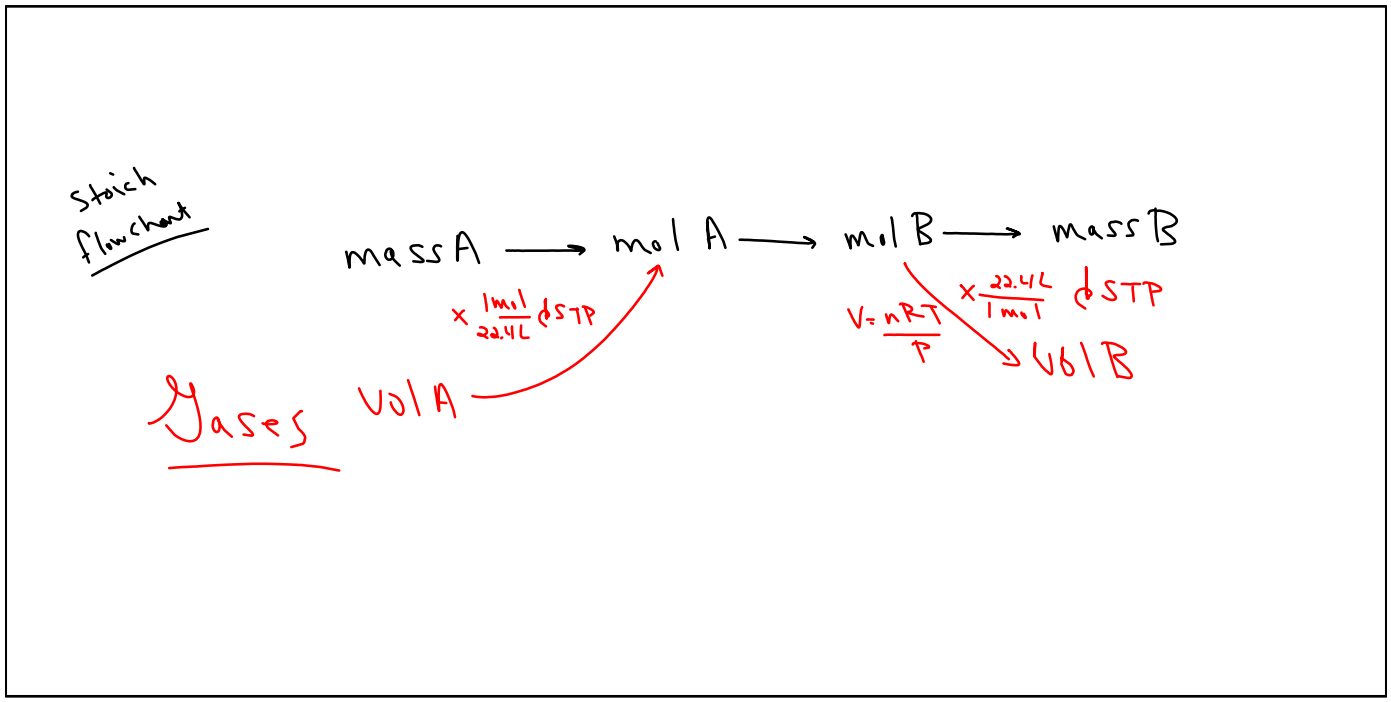
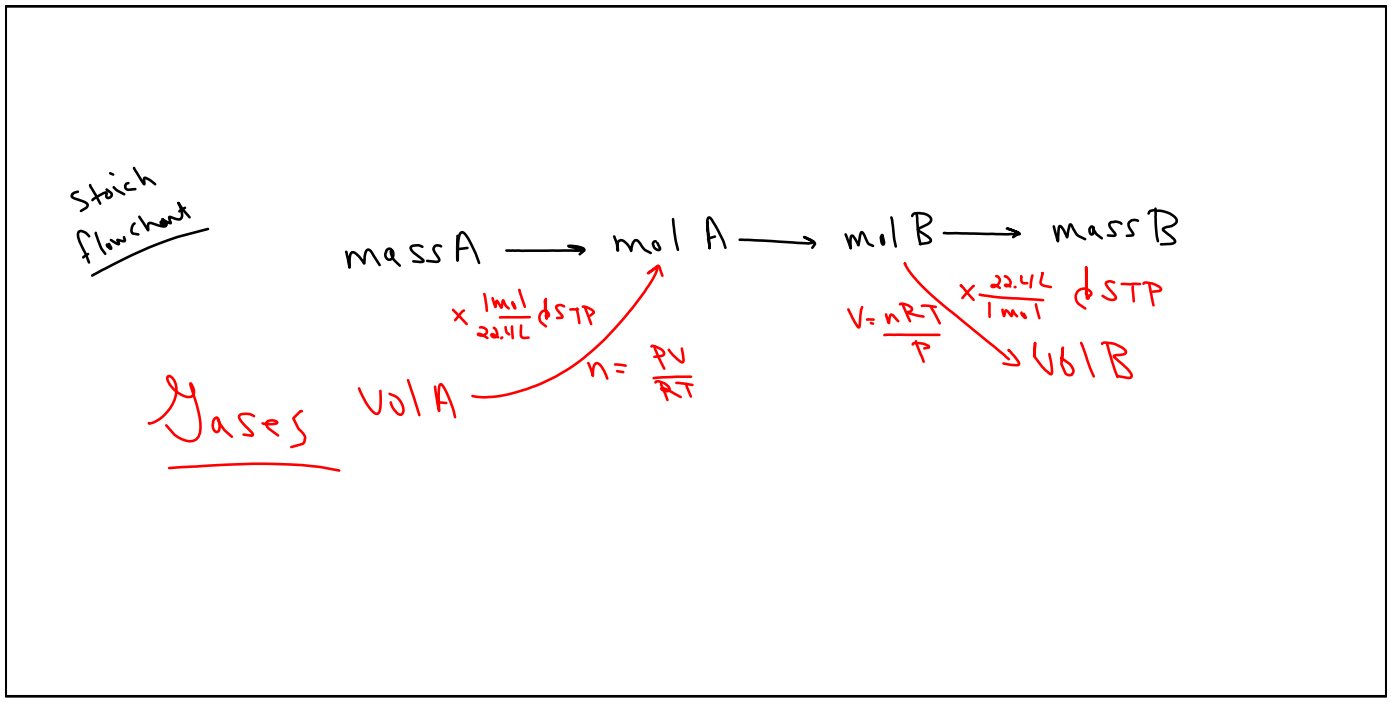
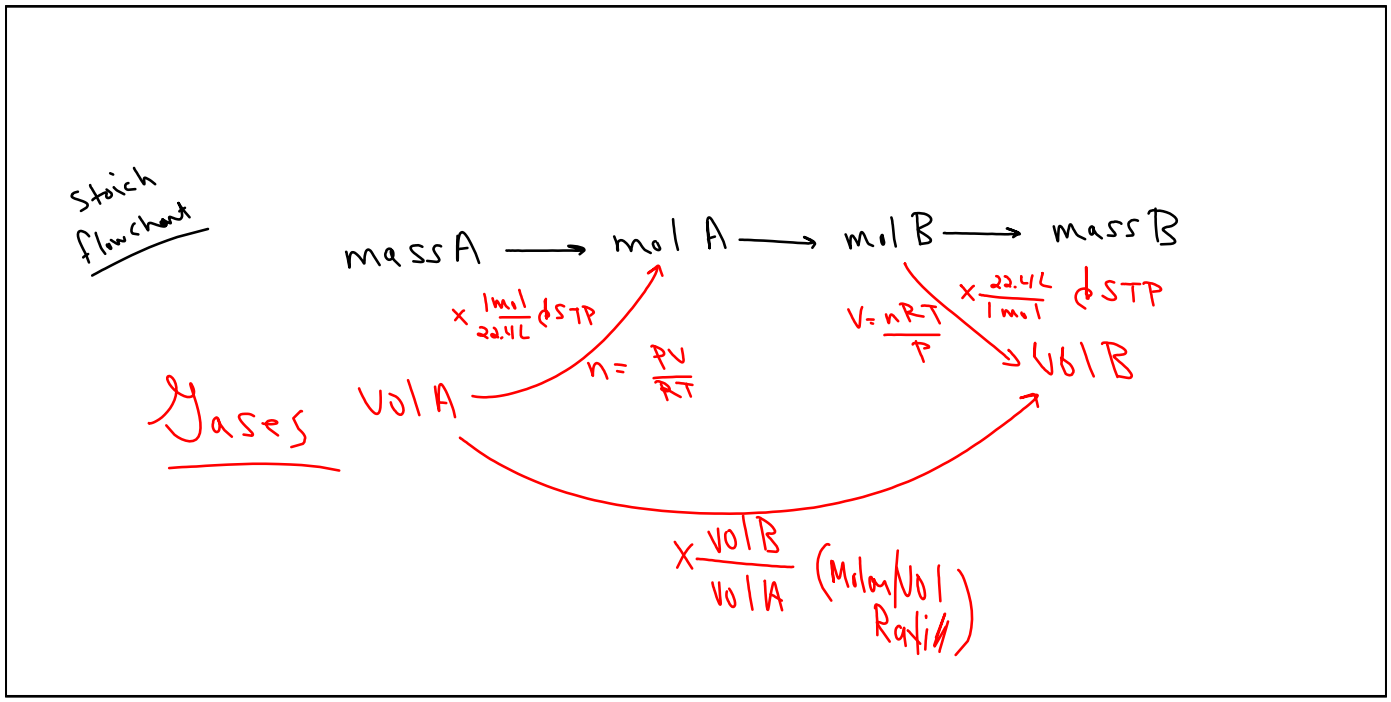


Gases


Stoich flowchart
mass A
mol A
mol B
mass B
V = nRT / P
x 22.4L / 1 mol @ STP
Vol B
Gases
Vol A


Stoich flowchart
mass A
mol A
mol B
mass B
$\times \frac{1\text{mol}}{22.4\text{L}}$ @STP
$\times \frac{22.4\text{L}}{1\text{mol}}$ @STP
$V = \frac{nRT}{P}$
Vol B
Gases
Vol A


Stoich flowchart
mass A
mol A
mol B
mass B
× 1mol / 22.4L @STP
× 22.4L / 1mol @STP
V = nRT / P
n = PV / RT
Gases
Vol A
Vol B


Stoich flowchart
mass A
mol A
mol B
mass B
× 1mol/22.4L @STP
n = PV/RT
V = nRT/P
× 22.4L/1mol @STP
Gases
Vol A
Vol B
× Vol B/Vol A (Molar/Vol Ratio)

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

If 12.5 g of HCl
React what vol
of H_2 is produced if
the P is 1.3 atm + T is
25°C?

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

"If 12.5 g of HCl react what vol of H_2 is produced if the P is 1.3 atm + T is 25°C?

$12.5\ g\ HCl \times \frac{1\ m.l\ HCl}{36.5\ g\ HCl}$

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

If 12.5 g of HCl react what vol of H_2 is produced if the P is 1.3 atm & T is 25°C?

$$12.5\ g\ HCl \times \frac{1\ mol\ HCl}{36.5\ g\ HCl} \times \frac{1\ mol\ H_2}{2\ mol\ HCl}$$

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

If 12.5 g of HCl react what vol of H_2 is produced if the P is 1.3 atm & T is 25°C?

$$12.5\ g\ HCl \times \frac{1\ mol\ HCl}{36.5\ g\ HCl} \times \frac{1\ mol\ H_2}{2\ mol\ HCl} = 0.18\ mol\ H_2$$

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

If 12.5 g of HCl react what vol of H_2 is produced if the P is 1.3 atm & T is 25°C (298K)?

$12.5\ g\ HCl \times \frac{1\ mol\ HCl}{36.5\ g\ HCl} \times \frac{1\ mol\ H_2}{2\ mol\ HCl} = 0.18\ mol\ H_2$

$V = \frac{nRT}{P} = \frac{(0.18\ mol)\left(0.0821 \frac{L\ atm}{mol\ K}\right)(298\ K)}{1.3\ atm}$

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$= 3.38\ L$